SECONDARY SUBMICROMETER IMPACT CRATERING ON THE SURFACE OF ITOKAWA.

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The samples returned by the Hayabusa spacecraft from near-Earth asteroid 25143 Itokawa show a large variety of nanometer-scale surface features related to space weathering by the solar wind and micrometeoroid impact [1-4]. Particle RA-QD02-0265 displayed a unique abundance of 15 submicrometer-sized (≤500 nm) impact craters [5], which are rarely observed among the Hayabusa samples. We studied particle RA-QD02-0265 extensively by FE-SEM, FE-EPMA, and TEM.

RA-QD02-0265 consists of intensely twinned diopside with twin domains on the order of 100 nm width, visible as striations on the particle's surface. The twin planes are associated with stacking faults and abundant partial dislocations, indicating them to be of mechanical origin during shock compression. The host rock of RA-QD02-0265 was therefore subjected to a large-scale shock event before break-up and exposure of the individual particle to the space environment on the surface of 25143 Itokawa.

Intense (sub-)micrometer-scale impact cratering may suggest a long surface exposure and, hence, a long residence time of regolith material on the surface of small asteroids, bearing implications for the dynamical evolution of these bodies. However, our combined FE-SEM and FIB/TEM study shows that the record of solar wind-induced space weathering and the accumulation of solar flare tracks in RA-QD02-0265 are not exceptionally different from other Hayabusa particles with surface exposure ages estimated to be less than 1 ka [6,7]. A 500 nm wide crater on the surface of RA-QD02-0265 exhibits microstructural damage to a depth of 400 nm below its floor and contains residues of Fe–Ni metal, excluding a formation by space craft exhausts or curatorial handling. We conducted Monte-Carlo-type simulations and find that the geometrical clustering characterized by the mean distance between individual craters on the exposed surface of RA-QD02-0265 is unlikely random due to single impacts of nm-sized micrometeoroids. Considering all the evidence, we conclude that the craters have formed through the impacts of secondary projectiles (at least partially Fe-Ni metal) created in a nearby (micro-)impact event.

In addition to structural damage by the solar wind and deposition of impact-generated melts and vapors, secondary impact cratering on the submicrometer-scale is another potential mechanism to modify the spectral properties of individual regolith particles. The lack of extensively exposed regolith grains in the sample suite returned by Hayabusa supports a dynamic regolith on the surface of 25143 Itokawa.

References: [1] Noguchi T. et al. (2011) Science, 333,1121-1125. [2] Nakamura T. et al. (2012) PNAS, 109, E624-E629. [3] Noguchi T. et al. (2014) Meteorit. Planet. Sci., 49,118-214. [4] Matsumoto T. et al. (2016) Geochim. Cosmochim. Acta, 187, 195-217. [5] Harries D. et al. (2016) EPSL, 450, 337-345. [6] Keller L. P. and Berger E. L. (2014) Earth Planets Space, 66, 71. [7] Keller L. P. et al. (2015), European Planetary Science Congress 10, abstract 358.